Current Applied Science and Technology Vol. 18 No. 1 Jan.-Apr. 2018

Physicochemical Properties of Low Glycemic Index-High Fiber Rice Flour from Storage Rice Grain and Application on Chocolate Chip Cookies as Substitute for Wheat Flour

Tunsuda Parinya[1], Ubonrat Phomphang[1], Napaporn Deesnam[1] and Jirapa Pongjanta[2*]

[1]Department of Agro-Industry, Faculty of Science and Agricultural Technology, Rajamangala University of Technology Lanna, Lampang, Thailand
[2]Food Innovation Center, Agricultural Technology Research Institute, Rajamangala University of Technology Lanna, Lampang, Thailand

Received: 12 July 2017, Revised: 16 March 2018, Accepted: 28 March 2018

Abstract

Chocolate chip cookies are classified as a medium to high glycemic index food (60-75). Thus, the objective of this study was to develop low glycemic index-high fiber chocolate cookies by using low glycemic index-high fiber (LGI-HF) rice flour. The LGI-HF rice flour was produced from two- year storage amylose rice by enzymatically and physical modification. The LGI-HF rice flour had 12.61, 50.45 and 30.66 % of moisture content, degree of crystallinity, resistant starch content and 54.67 of estimated glycemic index, respectively. The LGI-HF rice flour was applied in the cookies formulation at 0, 5, 10, 15 and 20 % substituted for wheat flour. The result showed that 20 % of LGI-HF rice flour substitute of wheat flour was higher on total acceptance score by 30 panelists than the control cookies which contained 14.03, 5.99, 21.94, 1.55, 10.31, and 11.67 % of moisture, protein, fat, ash, fiber, carbohydrate and resistant starch content, respectively. An estimate glycemic index of the developed cookies was lower (60.63) than the control (72.01). Consumers test revealed that 99 % of the consumers accepted and decided to buy the developed chocolate chip cookies with 30 Baht per 100 grams.

Keywords: modified rice flour, glycemic index food, wheat flour

1. Introduction

Food industry is being challenged to re-formulate cookies products for optimal nutritional value, in response to some population sectors with particular nutritional necessities and making them as tasty as or better than the original. One way to achieve a healthy cookies product is to reduce of the calorie-laden ingredients, especially carbohydrate and increase dietary fibre. Carbohydrate-rich foods such as clear wheat flour have high glycemic indexes (GI) and are certainly not good for people with diabetes and cardiovascular disease. Previous studies showed that digested carbohydrate-rich diets resulted in a steady state of hyperglycemia and incidence of type 2-diabetes. While, some carbohydrates break down more slowly, releasing glucose gradually into blood streams and having lower glycemic indexes [1, 2]. The concept of glycemic index (GI) was classify carbohydrate-based foods according to their postprandial glucose responses. The GI is defined as

[*]Corresponding author: Tel.: 066 838 657 722 Fax: 066 54 342 553
E-mail: jiratawan@gmail.com

low glycemic index food ingredients are derived from enzymatically and physical modification of high amylose rice flour in the form of resistant starch type III [5, 6]. Resistant starch (RS) is described as starch that escapes digestion in the small intestine [7]. RS can be found in nature and its contents of RS are varied by botanical source and starch granular structure (resistant starch type I and II). In addition, resistant starch can be produced from retrogradation of gelatinized starch known as resistant starch type III (RS III). RS III has been reported that starch retrogradation could result in a reduction of GI value, due to the increased resistance to digestive enzymes [8]. Thailand is the major rice producing country and the largest rice exporter with the export volume of about 5-6 million tons per year. Recently news form Thai government paddy mortgage project reported that over two-year storage rice from rice milling factory involved in the paddy mortgage project was low quality. Thus, on order to increase the value of this rice by means of utilizing it as raw material for production of low glycemic index-high fiber (LGI-HF) rice flour and its utilization in chocolate chip cookies are interested. Chocolate chip cookies contain complex fat emulsion system including flour, sugar, fat, eggs and baking powder. A proper combination of the ingredients can give a high quality product with desirable flavour and texture. Chocolate chip cookies is a food well-liked by consumers all over the world. However, due to its high glycemic index, over-consumption may contribute to chronic diseases. Previous study [8] revealed that the glycemic indexes of chocolate chip cookies products vary continuously form about 76 to over 80/ 100 g. In order to reduced glycemic index in the product. Thus, the objective of this work was investigate an optimum condition for LGI-HF rice flour production from rice milling factory under Thai government paddy mortgage project. The utilization of LGI-HF rice flour as wheat flour replacement on the physiochemical properties, sensory evaluation, resistant starch content, estimated glycemic index of the developed Chocolate chip cookies were studied.

2. Materials and Methods

2.1 Materials

High amylose rice grain (mixed rice between Hompratum and Chainat varites) which was stored for over 2 years in factort silostorage was supplied by Nitinansupakit rice milling, Phijit province Thailand. All-purpose wheat flour, butter, salt, sugar, baking powder, egg, fructose corn syrup (HFCS-55) brown sugar, dark and white chocolate chip were purchased from supermarket in Lampang province, Thailand.

Food grade pullulanase debranching enzyme (2,000 Units/mL) was obtained from Yojobio, China). Resistant starch assay kit (Megazyme) was obtained from Megasyme International Ireland Ltd., Ireland. Pepsin (EC 3.4.23.1; 2,980 unit/mg), α- amylase (E.C. 3.2.1.1; Type VI-B from hog pancreas; 20.4 unit/mg) and amyloglucosidase (A-3042; 69.65 unit/mg, from *aspergillus niger*), Glucose (GO) assay kit (GAGO-20) were purchased from Sigma Chemical Company, USA.

2.2 Modification of low glycemic index high fiber (LGI-HF) rice flour

The three replications of the over two- year storage rice grain samples were soaked for 4 h and water drain before dried at 50 ºC for 4 h. Afterward the rice grain was ground using a Cyclotec mill (Cyclotec TM 1093, Foss, Sweden) and sieved through a 100 micrometer sieve. The rice flour samples were molecular and physical modification as described in Patsanee *et al*. [9] to produced LGI-HF rice flour as following method. The 50 liter of 15 % gelatinized high amylose rice flour suspension was molecular modified by food grade pullulanase debranching enzyme (5 unit /g rice flour) at 55 °C for 4 h and deactivated enzyme by increased temperature to 95 ºC for 15 mins. Afterward, the debranched rice flour was cooling to 4 ºC followed by one cycle of freeze-thawed process (-10/30 °C). Degree of syneresis, production yield, moisture content and resistant starch content were examined according to Karim *et al*. [10] (2000) and AOAC [11] by Resistant starch assay kit (Megzyme), respectively. Microscopic images of LGI-HF rice samples were examined using SEM with magnifications of 5000x [12]. X-ray diffraction patterns of the four rice flour samples were measured with copper K_2 radiation (λ =0.154 nm) using a diffractometer (JEOL,JDX-3530, Japan), operated at 300 mA and 30 kV, 2θ range from 0 to 50.0 ° with a step size 0.05 ° and a count time of 2s. The data was analyzed with a MDI Jade 6.5 (Japan) program. The crystallinities of the rice flour samples were calculated as the proportion of crystalline area to total area at angles between 12 to 47 ° 2θ [13].

2.3 Preparation of Chocolate chip cookies

Chocolate chip cookies formulation system (100 % component) was set at 37.03, 8.64, 6.12, 18.51, 1.23, 0.6, 12.34 and 15.43 % of wheat flour, chocolate chip, raisin, butter salt, baking soda, vanilla, sugar and egg, respectively. The LGI-HF rice flour was replaced to wheat flour at 0, 5, 10, 15 and 20 %. First, the butter was beaten on level 3 (medium speed) with the paddle attachment in a Kitchen Aid® stand mixer for 5 min and then combined with brown sugar, corn syrup and whole egg and beaten to form moist peaks. Next, sifted wheat flour, LGI-HF rice flour, salt, baking powder and chocolate chip were added and well mixed with beater until all of the ingredients were incorporated into the batter. The mixed batter were wrapped and keep at 10 °C in refrigerator for 16 h. Afterward, the cookies dough was scooped up a golf ball size with a spoon and dropped onto a cookie sheet and then ten pieces of cookies were measured diameter with digital vernier. Put the cookies in the oven and baked for 10 mins in a 350 °F Hotpoint electric oven. The cookies were allowed to cool for 30 mins and the diameters were measured with digital vernier. The rest of the cookies was packed in low-density polyethylene for future physiochemical analysis and sensory evaluation.

2.4 Physiochemical analysis and sensory evaluations

The spread ratio was calculated using the formula: diameter of chocolate chip cookies divided by height of chocolate chip cookies [14]. Chocolate chip cookies color and hardness value were measured after cooling for 1 h at room temperature. The 3 replications of color value chocolate chip cookies were measured using a Minolta spectrophotometer (Minolta, Co. LTD, Japan) which was measurement of the lightness/brightness or whiteness, (L^*) where black is no reflection and white is perfect diffuse reflection; greenness-redness (a^*), in which negative values indicate green and positive values indicate red, and blueness-yellowness (b^*), where negative values indicate blue and positive values indicate yellow. Furthermore, the hardness value of each chocolate chip cookies sample was measured by using Texture Analyzer (TA-XT Plus, Stable Micro Systems, Surre, UK) within 24 h after baking. Instrument settings were compression mode; sharp cutting blade probe type HDP/BS blade set was used. The parameter used was at pretest speed 2.0 mm/s; post-test speed 5.0 mm/s; test speed 1.0 mm/s; and auto trigger type.

Sensory evaluations were conducted by 30 trained panelists consisting of Rajamangala University of Technology Lana's staff members and students. The chocolate chip cookies samples were evaluated based on likeness score of their appearance, odor, flavors, texture and total acceptance by a hedonic 9-point scale where 9 means most liked and 1 means most disliked [15].

2.5 Nutritive value of chocolate chip cookies analysis

Nutrition compositions of the control and developed chocolate chip cookies were analysed for moisture, protein, fat, ash, crude fiber and carbohydrate content according to AOAC method [11]. Total energies in the control and developed chocolate chip cookies were calculated by multiplying the number of gram of carbohydrate, protein and fat by 4, 4 and 9, respectively. Then sum of the results together to get a total energy as kcal/100 grams cookies [16].

Resistant starch (RS) contents in the control and developed **c**hocolate chip cookies samples were determined using a Megazyme Resistant Starch kit [17]. The samples were incubated in a shaking water bath with pancreatic α-amylase and amyloglucosidase for 16 h at 37 °C to hydrolyzed digestible starch to glucose. The reaction was terminated with 4 ml ethanol and the indigested RS

III was recovered by centrifugation (5000 *g*, 10 min). The supernatant was then decanted and washed with 50 % ethanol twice to remove the digested starch. The sediment was solubillized in 2 ml of 2 M KOH in an ice bath, neutralized with 8 ml sodium acetate (1.2 M) and the RS hydrolyzed to glucose with of amyloglucosidase (0.1 ml, 3300 U/ml). The glucose oxidase/peroxidase reaction was used to measure glucose released from the digested and resistant starches. Absorbance was read at 510 nm after a 20 min incubation period at 50 °C. Resistant starch and digested starch were calculated as glucose × 0.9. The total starch was calculated as the sum of resistant starch and digested starch.

In vitro starch hydrolysis and glycemic index (GI) in the control and developed **c**hocolate chip cookies samples were determined according to Goňī, *et al.* [18] with slightly modification. Using the hydrolysis curve (0-180 min), the hydrolysis index (HI) was calculated as the percentage of total glucose released from the samples, to that released from white bread. The glycemic index of the samples was estimated according to the equation: GI = (39.71+0.549) × HI.

2.6 Consumer test

Consumer test was done by 100 consumers from Lampang province, Thailand. Consumer testing consisted of a paper ballot questionnaire probing consumer perception of developed chocolate chip cookie and control cookies products on decided to buy and acceptability of the cookies appearance, odor, flavors, texture and overall preference by a hedonic 9-point scale where 9 means most liked and 1 most disliked data were analyzed according to Lawless and Heymann [15]

2.7 Statistical analysis

Completely Randomized Design (CRD) was used to evaluate the data means of physical properties of chocolate chip cookies samples. Randomized Completely Block Design (RCBD) was used to evaluate the means of sensory scores of the chocolate chip cookies samples. The data obtained for the physical properties and sensory evaluations were subjected to analysis of variance (ANOVA). Duncan's Multiple Range Tests procedure was used to compare differences between treatments [15]. The good quality and the highest total acceptance score of chocolate chip cookies sample were selected for further analysis on nutritional quality and consumer test compared with the control chocolate chip cookies sample. The consumer test data were analyze according to Lawless and Heymann [15].

3. Results and Discussion

3.1 Physicochemical properties of modified LGI-HF rice flour

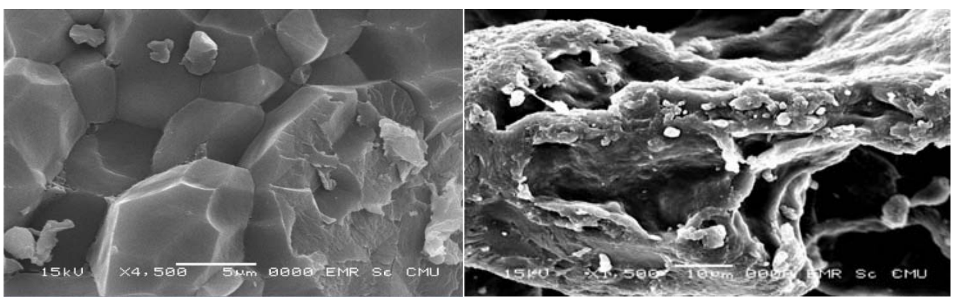
Physicochemical properties of over two-year storage amylose rice grain and modified LGI-HF rice flour samples are shown in Figures 1 to 4. According to the results, an appearance of storage amylose rice grain changed to yellow color after two-year storage at room temperature in rice mill factory, which was classified as low quality rice and cheaper price when compared with new rice grains.

An appearance of modified LGI-HF rice flour is shown in Figure 1. The color of rice flour sample (A) was yellowish, while the modified LGI-HF rice flour (B) was whitening. This results could be due to the process of enzymatically and physically modification of the over two year storage amylose rice grain that improved physical properties and nutritional quality of the rice sample.

(A) (B)

Figure 1. Appearance of samples from two-year storage amylose rice grains and rice flour (A) and modified LGI-HF rice flour (B)

The morphological image of the two-year storage amylose rice flour and modified LGI-HF rice flour presented in Figure 2. Amylose rice flour granules have polygonal shapes with diameters between 3-5 μm. The surface of the granules was smooth with some surface erosion and slightly damaged due to long time storage in warming temperature while the LGI-HF rice flour formed a coarse filamentous network structure which is similar to the finding by Pongjanta *et al.* [7].



(A) (B)

Figure 2. Morphological image of samples from two-year storage amylose rice flour (A) and modified LGI-HF rice flour (B).

X-ray diffraction patterns of amylose rice flour and LGI-HF rice flour samples are shown in Figure 3. The diffraction pattern obtained from amylose rice flour was classified as an A-type pattern as indicated by typical peaks at 15.0, 17.5, 20.0 and 23.2 ^{o} of diffraction angle 2θ. The calculated crystallinity of native rice flour was 35.38 %. The value was in agreement with those reported for amylose rice flour [5, 7]. The amylose rice flour subjected to pullulanase debranching and retrogradation treatments displayed V-type diffraction pattern, with 50.45 % of crystallinity degree. This was attributed to debranching and retrogradation of amylose chain which reorganized the structure of starch into a helical complex to that of V-amylose pattern.

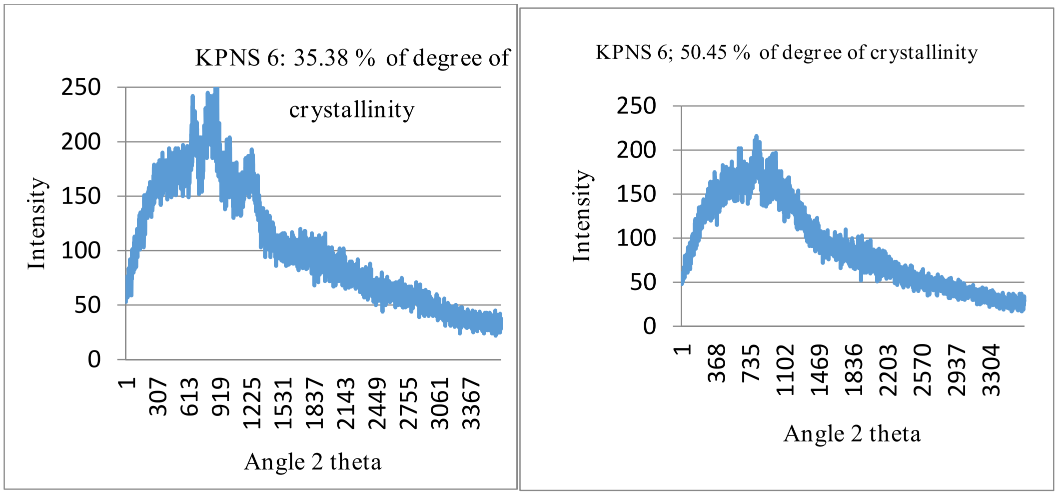


Figure 3. X-ray diffraction patterns of samples from two-year storage amylose rice flour (A) and modified LGI-HF rice flour (B).

Degree of syneresis, production yield, moisture content, degree of crystallinity, resistant starch, digested starch, total starch and estimated glycemic index of LGI-HF rice flour presented in Figure 4. The molecular and physical modified rice flour solution had 67.30 % and 99.78 % of syneresis degree and production yield, respectively. In addition, physicochemical properties of LGI-HF rice flour were 12.61 %, 50.45 %, 30.66 %, 53.14 %, 83.80 % and 54.67 % of moisture content, degree of crystallinity, resistant starch, digested starch, total starch and estimated glycemic index, respectively, which was higher than the previous studied [7, 19-21]. This might be cause by the long time storage of the rice grain sample.

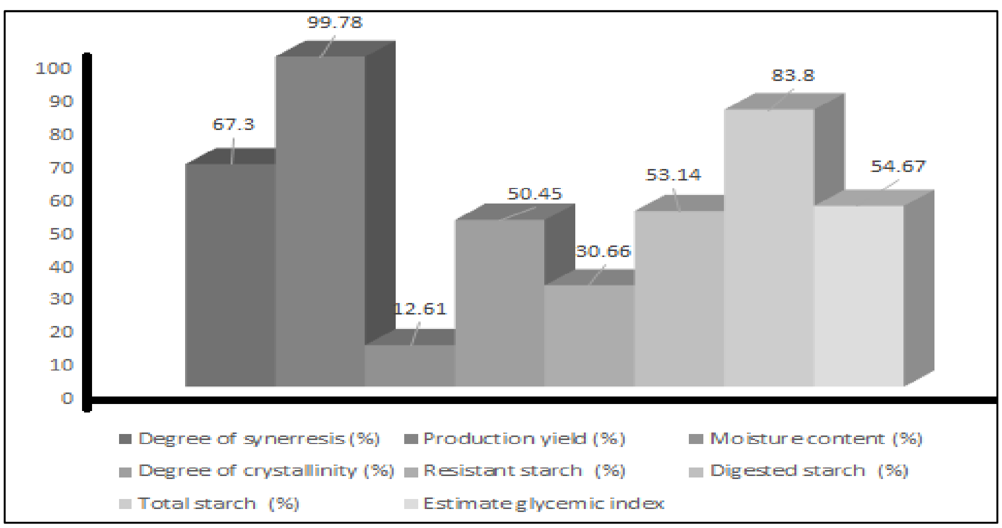


Figure 4. Physicochemical properties of modified LGI-HF rice flour from two-year storage rice grains

3.2 Physical properties of LGI-HF chocolate chip cookies

Table 1 presents the spread ratio, color value and hardness value of chocolate chip cookies with the substituted of LGI-HF rice flour at 0 - 20 % of wheat flour. The spread ratio exhibited non-significant variation between treatments within the range of 1.51-1.51. However, the control chocolate chip cookies gave higher spread ratio than those developed **c**hocolate chip cookies containing LGI-HF rice flour. This might be due to the reduced amount of gluten and the rapid heat input causes less spread of the developed **c**hocolate chip cookies containing LGI-HF rice flour. This result was consistent with the report of Savita *et al*. [14] who indicated that increasing the level of fiber from red and white bran decreased the cookie spread ratio.

The color values for the *L**, *a** and *b** coordinates of the control and LGI-HF chocolate chip cookie were 40.11-43.82, 11.46-13.54 and 26.66-29.83, respectively. The control chocolate chip cookies had the greatest redness (a*), and yellowness (b*) compared to LGI-HF chocolate chip cookies. In addition, the hardness value of LGI-HF chocolate chip cookie was significantly different ($p<0.05$) with the variation of LGI-HF rice flour content. The hardness value increased when the LGI-HF rice flour content increased from 320.68 to 403.27 N. This was because of LGI-HF rice flour producing high absorption dough tend to be hard cookies structure. Similar study reported that more strength was needed to break cookies incorporated with legumes flour with high amounts of resistant starch [22].

Table 1. Physical properties of LGI-HF chocolate chip cookies

LGI-HF rice flour (%)	Physical properties				
	Spread ratio	Color value			Hardness value (N)
		*L**	*a**	*b**	
0 (control)	1.51±0.15^{ns}	41.25±0.29^{ns}	13.54±1.88^{bc}	29.83±2.04^{ns}	320.68±64.5^{c}
5	1.56±0.11	43.82±1.50	12.58±1.57^{bc}	28.02±2.53	379.62±86.3^{ab}
10	1.55±0.29	42.78±1.17	12.97±2.07^{ab}	28.92±2.86	348.43±68.2^{b}
15	1.51±0.13	41.23±0.72	11.98±3.03^{a}	27.06±3.67	357.99±54.6^{b}
20	1.58±0.18	40.11±7.74	11.46±1.43^{c}	26.66±6.63	403.27±57.8^{a}
C.V (%)	1.54	6.03	2.37	3.49	27.34

^{ns}Means in a column are not significantly different ($p>0.05$)

^{a,b}Means in a column with a different upper script letter are significantly different ($p<0.05$)

3.3 Sensory evaluation of LGI-HF chocolate chip cookies

The mean sensory evaluation scores for appearance, color, odor, flavor, crust crispy, crumb softness and total acceptance of chocolate chip cookies which wheat flour was replaced with rice flour at 0, 5, 10, 15 and 20 % of LGI-HF rice flour as shown in Table 2. There were not significant ($p>0.05$) scores in the appearance, color, odor, flavor and crumb softness for both experimented cookies. In terms of crust crispy and total acceptance score, the mean scores increased as the level of LGI-HF rice flour increased, with 20 % LGI-HF rice flour having the highest mean score. This indicated that as the percentage of LGI-HF rice flour increased, the crust cookie's crispiness and total acceptance score improved. Thus, the 20 % LGI-HF rice flour replaced of wheat flour and control chocolate chip cookies were selected and subsequently used for nutritional analysis and consumer test.

3.4 Nutritive value of chocolate chip cookies

The chemical composition of control and chocolate chip cookies made from 20 % of LGI-HF are summarized in Table 3. The LGI=HF chocolate chip cookies was higher in moisture content, crude fiber and resistant starch content but lower in carbohydrate and total energy than the control chocolate chip cookies. In addition, the LGI-HF chocolate chip cookies were not significantly different (p>0.05) in fat, ash and protein content from the control chocolate chip cookies which was ranged from 2.14 to 2.16 %, 1.38 to 1.55 % and 5.84 to 5.89 %, respectively.

Table 2. Sensory evaluation result of LGI-HF chocolate chip cookies

LGI-HF (%)	9 Point Hedonic Scaling Test						
	Appearance	Color	Odor	Flavor	Crust crispy	Crumb softness	Total acceptance
0 (control)	7.37± 2.14^{ns}	7.27± 1.43^{ns}	7.43± 2.13^{ns}	7.33 $\pm1.84^{ns}$	6.23± 2.84^{b}	7.17± 2.15^{ns}	7.01± 2.24^{c}
5	7.17± 2.10	7.17± 2.12	7.20 ±1.28	7.13± 2.44	6.70± 2.42^{ab}	7.4± 2.22	7.34± 2.12^{b}
10	7.33± 1.24	7.40± 3.14	7.3 3± 2.91	7.20± 3.44	6.67± 2.64^{ab}	7.37± 2.24	7.43± 2.62^{ab}
15	7.27 ±2.05	7.10± 1.34	7.43± 4.24	7.13± 4.22	6.67± 3.52^{ab}	7.44± 2.31	7.40± 2.24^{b}
20	7.23± 2.32	6.97± 1.74	7.30± 4.14	7.20± 3.24	6.77± 2.34^{a}	7.50± 2.24	7.57± 2.64^{a}
C.V (%)	5.99	2.59	7.33	9.64	5.57	4.36	5.74

^{ns}Means in a column are not significantly different (p>0.05)

^{a,b}Means in a column with a different upper script letter are significantly different (p<0.05)

Table 3. Chemical composition of LGI-HF chocolate chip cookies and control

LGI-HF rice flour (%)	Chemical composition (%)						Total energy (kcal)	Resistant starch content (%)
	Moisture	Fat	Crude fiber	Ash	Protein	CHO		
0 (control)	12.66± 0.52^{b}	2.16± 0.51^{ns}	8.54± 1.09^{b}	1.38± 0.53^{ns}	5.84± 0.44^{ns}	69.42 ± 2.12^{a}	320.48± 4.82^{a}	2.01± 0.22^{b}
20	14.03 ± 0.14^{a}	2.14± 1.06	10.31± 2.09^{a}	1.55± 0.15	5.89 ± 0.092	65.98± 1.24^{b}	179.30± 3.85^{b}	3.63± 0.18^{a}
C.V (%)	2.57	2.31	2.46	3.79	2.30	2.15	4.37	1.37

^{ns}Means in a column are not significantly different (p>0.05)

^{a,b}Means in a column with a different upper script letter are significantly different (p<0.05)

In vitro starch hydrolysis rate and estimated glycemic index of control and LGI-HF chocolate chip cookies were shown in Table 4. An Area Under Curve (AUC) from the starch hydrolysis rated from 0 to 180 min of the LGI-HF chocolate chip cookies samples divided by AUC of white bread revealed that AUC of LGI-HF chocolate chip cookies was significantly (p<0.05) lower than the control chocolate chip cookies. The hydrolysis index of 20 % LGI-HF rice flour in chocolate chip cookies was lower (50.69 %) than the control (58.84 %). Furthermore, an estimated glycemic index (EGI) value for the LGI-HF chocolate chip cookies was significantly ($p \leq 0.05$) lower (60.63) than the control chocolate chip cookies (72.01). Jenkins *et al*. [2] classified glycemi index (GI) value that the value at 70 or more is high, a GI of 56 to 69 inclusive is medium, and a GI of 55 % or less is low. Thus, the 20 % LGI-HF rice flour chocolate chip cookie was classified as a mediume GI food.

Table 4. *In vitro* starch hydrolysis rate and estimated glycemic index of the control and LGI-HF chocolate chip cookies.

LGI-HF rice flour (%)	*In vitro* starch hydrolysis rate		
	Area under curve	Hydrolysis index	Estimated glycemic index
0	1,654.87 ±18.05[a]	58.84±6.43[a]	72.01±3.53[a]
20	1,461.85 ±11.37[b]	50.69±6.44[b]	60.63±3.54[b]
C.V (%)	11.03	11.02	4.79

[a,b]Means in a column with a different upper script letter are significantly different ($p<0.05$)

3.5 Consumer test of the LGI-HF chocolate chip cookies

The questionnaires for the LGI-HF chocolate chip cookies were collected and data were analysed. Most consumers were ladies (71 %) with average age between 20-25 years and had a diplomas and bachelor degrees. Among them were students and private businessman which was had average monthly income of 2,000 to 10,000 baht. Almost 96 % of the consumers had been eating chocolate chip cookies and 55 % of them buying from local supermarket around 2-3 times a week. Most consumers (100 %) have never eaten LGI-HF chocolate chip cookies. The mean scores of 9 point hedonic scale on appearance, color, odor flavor, texture, mouth feel and total acceptance of developed LGI-HF chocolate chip cookies by 100 consumers were medium like within the range of 7.27-7.78 point (Figure 5). In addition, the 100 % of the consumers accepted and decided to buy the LGI-HF chocolate chip cookies products at 30 Baht per 100 grams (Figure 6).

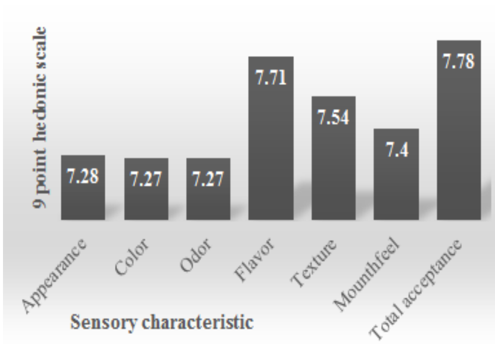


Figure 5. Nine point hedonic liking scale of LGI-HF chocolate chip cookies by 100 consumes.

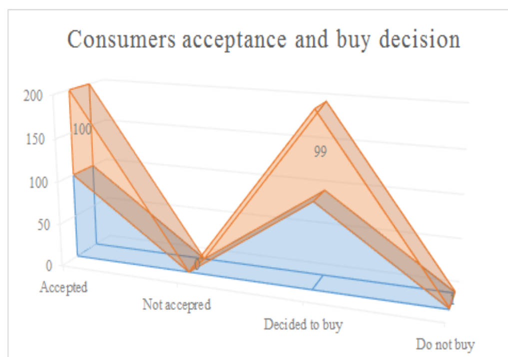


Figure 6. Consumers acceptance and decision to buy the LGI-HF chocolate chip cookies.

4. Conclusions

This study revealed that the enzymatically and physically modified amylose rice grain (two- year storage) enhanced the physical properties and nutrition quality in the form of LGI-HF rice flour. The 20 % of LGI-HF rice flour in substitution of wheat flour significantly enhanced crude fiber content in chocolate chip cookies. The LGI-HF chocolate chip cookies had lower energy content and estimated glycemic index than the control cookies sample. A composite of LGI-HF rice flour and wheat flour increased dietary fiber in the form of resistant starch from 2.01 to 3.63 % per 100 g of the cookies products consumed and reduced estimate glycemic index from 72.01 to 60.63. The

LGI-HF chocolate chip cookies products were accepted by 100 % consumer group and decided to buy the product at 30 Baht per 100 grams.

5. Acknowledgements

This research was supported by the National Research Council of Thailand. The authors acknowledge the valuable laboratory support from the Science and Technology Service Center, Faculty of Science, Chiang Mai U niversity, Thailand and Nitinansupakit Rice Milling, Phichit province, Thailand for supplying amylose rice grains.

References

[1] Truswell, A.S., **1992**. Glycaemic index of foods**.** *European Journal of Clinical Nutrition*, 46, (S1) S91-S101

[2] Jenkin, C., Kendall, W., Augustin, L.S., Franceschi, S., Hamidi, M., Marchie, A., Jenkins, A.L. and Axelsen, M., **2002**. Glycemic index: overview of implications in health and disease. *American Journal of Clinical Nutrition,* 76, 266S-273S.

[3] Frei, M., Siddhuraju, P. and Becker, K., **2003**. Studies on the in vitro starch digestibility and the glycemic index of six different indigenous rice cultivars from the Philippines. *Food Chemistry*, 83, 395-402.

[4] Roberts, S.B., **2000**. High Glycaemic Index Foods, Hunger and Obesity: Is there aconnection. *Nutrition Review*, 5(6), 163-169.

[5] Pongjanta, J., Utaipatanacheep, A., Naivikul, O. and Piyachomkwan, K., **2008**. Enzymes-resistant starch (RS III) from Pullulanase-debranched high amylose rice starch. *Kasetsart Journal Natural Science,* 42 (5; Suppl I), 83-92.

[6] Topping, D.L. and Clifton, P.M., **2001**. Short-chain fatty acids and human colonic function: Roles of resistant starch and non-starch polysaccharides. *Physiology Review,* 81, 1031-1064.

[7] Pongjanta, J, Utaipatanacheep, A., Naivikul, O. and Piyachomkwan, K., **2008**. Debranching enzyme concentration effected on physicochemical properties and glycemic index of resistant starch type III from high amylose rice starch. *Carbohydrate Polymer,* 78, 5-9.

[8] Willet, W., Manson, J. and Liu, S., **2002**. Glycemic index, glycemic load, and risk of type 2 diabetes. *American Journal of Clinical Nutrition*, 76 (1), 274S-280S.

[9] Patsanee, M., Jintana, S., Ubonrat, P. and Jirapa, P., **2016**. Formulae development of Low GI and High Fiber muffin product.12th Naresuan research: Research and Innovation for Country Development. **In:** Science and Technology group, Naresuan University, 21-22 July 2016. 290-298 Phisanulok, Thailand

[10] Karim, A.A., Norziah, M.H. and Seow, C.C., **2000**. Methods for the study of starch Retrogradation. *Food Chemistry*, 71, 9-36.

[11] Association of Official Analytical Chemistry **2002**. *Official Methods of Analysis*. 18th ed. Method 2002.2. Arlington VA.

[12] Atichokudomchai, N., Shobsngob S. and Varavinit, S., **2000**. Morphological properties of acid-modified tapioca starch. *Starch/ Stärke*, 52, 283-289.

[13] Cheetham, N.W.H. and Tao, L., **1998**. Variation in crystalline type with amylose content inmaize starch granules: An X-ray powder diffraction study. *Carbohydrate Polymers*, 36, 277-284,

[14] Savita Sharma, Jatinder Pal Gupta, H.P.S. Nagi, and Rakesh Kumar, **2012**. Effect of incorporation of corn byproducts on quality of baked and extruded products from wheat flourand semolina. *Journal Food Science Technology,* 49(5), 580-586.

[15] Lawless, H.T. and Heymann, H., **1998**. *Sensory Evaluation of Food: Principles and Practices,* International Thomson Publishing, New York.

[16] Helen, A.G. and Mary, F.P., **1995**. Human Nutrition. 2nd ed. Von Hoffmann Press, Inc. United States of America

[17] Association of Official Analytical Chemistry. **2002**. *Official methods of analysis*. *Method 2002.2* (18th ed.) Arlington VA. USA.

[18] Goni, I., Garcia-Aolnso, A. and Saura-Calixto, F., **1997**. A starch hydrolysis procedure to estimate glycemic index. *Nutrition Research*, 17, 427-437.

[19] Yin, H., Alias, L., Karim, A. and Norziah, M.H., **2007**. Effect of pullulanase debranching of Sago starch at sub gelatinization temperature on the yield of resistant starch. *Starch/ Stärke*, 59, 21-32

[20] Miller, J.B., Pang, E. and Broomhead, L., **1995**. The glycaemic index of foods containing sugars: comparison of foods with naturally-occurring v. added sugars. *British Journal Nutrition*, 73*,* 613-623.

[21] Sopade, P.A. and Gidley, M.J., **2009**. A rapid In-vitro digestibility assay based on glucometry for investigating kinetics of starch digestion. *Starch/Stärke,* 61, 245-255.

[22] Noor Aziah, A.A., Mohamad Noor, A.Y. and Ho, L.H., **2012**. Physicochemical and organoleptic properties of cookies incorporated with legume flour. *International Food Research Journal*, 19(4), 1539-1543.